TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 746

THE HIGH-SPEED HEINKEL HE 70 MAIL AIRPLANE

By Ernst Heinkel

Zeitschrift für Flugtechnik und Motorluftschiffahrt
Vol. 24, No. 24, December 28, 1933

Washington
May 1934

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By Ernst Heinkel

In compliance with the request of the WGL I am pleased to speak today on the subject of high-speed aircraft.

Greater flying speed is one of the most pressing problems in commercial airplane design, since its sole advantage over other vehicles of transportation lies in its speed.

Aerodynamically superior high-speed airplanes have the advantage over the usual commercial airplanes of the same horsepower in that the mileage within a stated time, with the same personnel, the same fuel consumption, engine depreciation and servicing is considerably greater.

The first attempts of modern high-speed mail airplane design were made by Lockheed in the United States in 1928.

The high-wing "Air-Express" had a speed of 258 km/h (160.3 m.p.h.) with a full load of 1735 kg (3,825 lb.) and 410 hp. The following year its speed was increased to 269 km/h (167 m.p.h.). The use of an N.A.C.A. cowling and other refinements raised it to 282 km/h (175.2 m.p.h.). (See table I.)

In 1931 the Lockheed "Vega" reached 288 km/h (179 m.p.h.) with 2,143 kg (4,725 lb.) and 420 hp. The low-wing "Sirius" with a full load of 2,360 kg (5,203 lb.) and 420 hp. reached a speed of 280 km/h (174 m.p.h.).

Lockheed's next monoplane, the "Orion", of 1931, had a top speed of 358 km/h (222.5 m.p.h.) at 2,140 m (7,020 ft.) with 500 hp. and 2,360 kg (5,203 lb.) full load; and a speed of 345 km/h (214.4 m.p.h.) near ground level.

Two other firms, the Consolidated and the Northrop also appeared on the field, but they have been unable to equal the performance of the Lockheed "Orion".

*"Schnellpostflugzeug He 70." Z.F.M., December 28, 1933, pp. 669-676.

The German experiments with high-speed mail airplanes began in 1930. The first two examples built in 1931, by two airplane companies had a top speed of 220 km/h (136.7 m.p.h.) and 255 km/h (158.4 m.p.h.) and were wholly outclassed by the American speeds. Even the use of more powerful engines did not remedy this. In fact, the jump of the United States over the other countries seemed at first so great as to raise doubts about the truthfulness of the given performances. In a statement of the DVL of October 1931 on the greater speed of transport and mail airplanes, it was said that the high speed of the American mail airplanes could not be solely due to greater power per unit area, but that they also must be better aerodynamically.

A convenient criterion of comparison for the aerodynamic quality of high-speed aircraft of about even dimensions and used for about the same purpose is the high-speed index:

$$\frac{\eta}{c_w} = \frac{V^3}{75} \times \frac{\gamma_o}{2g} \times \frac{F}{N}$$

The maximum speed V is no direct criterion for the aerodynamic quality, because it is also possible to raise the speed by increasing the wing power N/F (fig. 1).

In the graphical representation of the top speed of different airplanes versus wing power a comparison of the high-speed figures is equally possible.

Thus we find:

1) That up to the end of 1932 the high speed, as well as the high-speed index of the German transport airplanes were not very favorable; they ranged around $V = 200$ km/h (125 m.p.h.) and $\frac{\eta}{c_w} = 15$;

2) That the speed of the American airplanes ranged at 285 km/h (177 m.p.h.) and $\frac{\eta}{c_w} = 21.5$ to 25.8;

3) That the best high-speed mail airplane, the Lockheed "Orion" with 345 km/h (214.4 m.p.h.) at sea level and $\frac{\eta}{c_w} = 36.5$ was far superior.

Part of this 358 km (222.5 m.p.h.) speed of the "Orion" at 7,000 ft. was due also to its lower drag as a result of the retractable landing gear.

During the first negotiations with the R.V.M. and the Lufthansa in 1931, a top speed of 250 km/h (155.3 m.p.h.) was considered desirable, but subsequently a top speed of 320 km/h (198.8 m.p.h.) and a commercial speed of 265 km/h (164.7 m.p.h.) was decided upon.

The airplane to be constructed by us was to form an intermediate link, so as to exclude any risks. The result of these negotiations was the order, February 12, 1932, to design and build the He 65 with a guaranteed top speed of 285 km/h (177 m.p.h.) and a commercial speed of 238 km/h (147.9 m.p.h.).

The design had progressed very satisfactorily when the "Swissair" ordered the Lockheed "Orion". This fact made it imperative to try to equal and, if possible, even to exceed the performances of the Americans. I submitted the facts to the Secretary of State, Mr. Milch, who was then Director of the Lufthansa, and requested permission to modify the design of the He 65 so as to insure a much higher speed. He promptly concurred, and a month later, July 1932, we were able to submit the design for the now designated He 70 (fig. 2). The guaranteed performances were 314 km/h (195 m.p.h.) top speed and 288 km/h (179 m.p.h.) commercial speed. It was also agreed to use the same cabin dimensions, wing loading and landing speed as the Americans and to postpone improvements until later. The principal thing was to be high speed.

The minimum fuselage cross section of a commercial airplane is that needed for the cabin which, in the present case, was to house a crew of 2, 5 passengers and baggage.

The drag of this fuselage together with the wing must be so much lower as the portion of the wing hid in the fuselage is greater. The wing portions lying in the fuselage must, of course, not disturb the cabin space, thereby necessitating a larger fuselage cross section.

The chosen cantilever low-wing design filled the requirement of minimum total drag with most favorable use of fuselage section as cabin. This low-wing type is unlike that of Junkers (Patent No. 310,619). It is aerodynamically better for the fuselage section does not equal the usable cabin cross section plus the frontal area of wing structure, but it only equals the usable cabin cross section; the spars are mounted appropriately without reducing the usable cabin space.

Interference drag can be effectively lowered by suitable fillets. But the lowest drag is obtained by so mounting the wings as to insure low interference drag even without the use of fillets. For this reason the wings were attached to the fuselage so that the upper side of the wing and the fuselage wall formed a very obtuse angle. The wing emerges from the fuselage with a pronounced anhedral which gradually changes into dihedral, so that ample lateral stability is assured.

The chosen wing loading was, similar to the American high-speed airplanes, 91 kg/m² (18.64 lb./sq. ft.) which evidently was satisfactory, for it is still being used. To simplify the design, save weight and assure high speed we first omitted the wing flaps. The first tests showed the He 70 to have very satisfactory landing characteristics; the landing speed was 104 km/h (64.6 m.p.h.) with maximum load, according to the DVL test data. But subsequently we installed flaps so as to be able to use small landing fields. The main purpose of the flaps was to spoil the gliding angle and through it to shorten the long taxi run. We decided on a small flap without any slot but with unusually large setting angle (70°). It increased the maximum lift coefficient 75 percent and spoiled the L/D 90 percent. In a comparative test of slot and flap the $c_{a\ max}$ was even increased 84.5 percent, but the L/D became only 52 percent poorer. A split flap which was also tried lowered the L/D 70 percent.

A further advantage when not using slots is that all linkages and supports can be housed within the wing, i.e., be made much more solid without increasing the drag. The success of the wing flap is best proved by the distance which the airplane needs from levelling off at 20 m (65.6 ft.) height to pull up. The best figures according to the DVL measurements on the He 70 are 860 m (2822 ft.) without flaps and 410 m (1345 ft.) with flaps. Another surprising fact is that the c_m of the airplane scarcely changes while operating the flaps, so that a setting of the stabilizer is superfluous.

One particular aim in the design of the He 70 was the best possible polar with a great $c_{a\ max}/c_{w\ min}$ ratio. The selection of the plan form, aspect ratio, etc., requires more than the purely aerodynamic conditions on the wing. It is clear, that plan forms with diminishing aspect ratio and fullness are statically more propitious, require less profile thickness and wing weight and thus become indirectly better aerodynamically also. After elaborate investigations a 1:6 aspect ratio was found to be best for the plan form of a high-speed mail airplane. Because of decreasing damping in roll and the geometrically increasing mean wing thickness it was decided not to make the fullness of the plan form less than $\pi/4$.

These requirements (aspect ratio 1:6, fullness π:4) for a 36.5 m^2 (392.9 sq. ft.) total area were met with an elliptic plan form of 14.8 m (48.56 ft.) span as large, and 3.14 m (10.3 ft.) maximum chord as small axis. A simple trapezoidal wing would have been altogether unsuitable on account of the necessary space for the retracted wheels. A smaller aspect ratio was unsatisfactory, because the necessary fuselage length increases as the mean geometric wing chord becomes greater and the fullness of the plan form becomes less. To make the fuselage longer and at the same time to assure an acceptable ground angle of the wing would either result in a very high retractable landing gear or in an unduly great wing incidence relative to the real fuselage axis, aside from the greater fuselage weight resulting from the greater wing moments about the lateral axis of the airplane and the longer fuselage. The thickness of the wing at its juncture with the fuselage is 17.5 percent of the chord. We took especial care to obtain high torsional stiffness and ample security against oscillations, which is always a difficult problem in cantilever-wing designs. The percentage profile thickness tapered considerably toward the wing tips. The camber was fitted at each point to the corresponding wing thickness, although the determination of the camber itself was effected mathematically, as well as the polars and the moment curves.

No wind-tunnel tests were made before the He 70 was completed. To improve the fineness of the lines which was not quite accurately known, would have entailed too many and very precise studies, aside from the fact that in our case it would not have obviated a conversion of the data to the actual airplane conditions.

Our method of calculation was based upon measurements from every known wind tunnel, with the change in profile drag with surface roughness and Reynolds Number between one tunnel and the other and the He 70 carefully allowed for. Even the data in the N.A.C.A. compressed-air tunnel would have to be converted first, because of the not inconsiderable change in drag. Such factors play, of course, no role in airplanes with the hitherto usual high drag because of the smallness of the changes involved, Moreover, there usually exist several contradictory inaccuracies between model test and airplane which have nothing to do with the profile, so that the omitted profile calculation is not very much missed. But for high-speed airplanes such as the He 70 this is very important.

The surprising fact however, is that several model tests made after the airplane had been built, revealed a practically perfect accord with the previously computed air loads.

The total drag coefficient obtained during these tests on a complete model was only half as high as that of the Lockheed "Altair" according to the data given in N.A.C.A. Technical Note No. 456. The "Altair" is, as we know, similar to the "Orion".

The improvement obtained is certainly not attributable to the lower parasite drag alone, since in the "Altair" - with landing gear retracted - this drag is only a part of the total drag. It is rather also due to the profile drag coefficient of the wings c_{wp}, which had been kept to a minimum on the He 70.

To obtain the speed of 377 km/h (234.3 m.p.h.) the whole design of the He 70 was executed with the greatest care in all details, and all parasite drag avoided wherever possible (fig. 3). (See table II.)

A comparison with the American express airplanes reveals the He 70 to be superior in speed, and that this superiority is due to its aerodynamic quality as expressed in the high-speed index $\eta/c_w = 52.8$, and not to higher wing power (fig. 4).

The fuselage is spindle-shaped. The power plants with their cowlings have been streamlined wherever possible; the cantilever control surfaces are elliptic in plan form.

The retraction of landing gear, tail wheel and radiator resulted in a 35 to 40 km/h (21.7 to 24.9 mi./hr.) higher speed. The use of ethylene glycol for engine cooling made it possible to reduce the frontal and cooling surface of the otherwise conventional radiator to one third, aside from a weight saving of 50 kg (110 lb.). The radiator - already very small - was slung below the fuselage so that it could be retracted when necessary. The bottom of the oil tank partitioned off from the tank proper, was used for cooling, the oil circulation between sump and oil cooler being maintained by means of a wing pump. It insured an 8° C cooling despite the comparatively small cooling surface.

Lastly, the wings, fuselage and control surfaces were shell-plated and flush-riveted. All fittings, door knobs, and foot steps are inset and the windows mounted flush.

The realization of an aerodynamic favorable wing design, especially at the points where the wing meets the fuselage, presented a very difficult feat. It was deemed best to build the wing of wood, and to use two spars, so that the retractable wheels fitted in between the spars. The continuous spars extend into two box-shaped recesses of the fuselage where they are bolted to the main frames.

The flanges of the box spars are of pine with spruce outside plies, the webs are laminated birch. The ribs are of spruce, and the aileron support ribs are boxes.

Despite the two-spar design, the wing is completely covered with plywood, except for the space required for the landing gear and for the mounting of the tank between the spars.

The stress analysis was made for a truss of two spars coupled with the torque tube which forms the covering. Each wing loading may be divided into a bending load applied in the elastic axis and stressing both spars quite uniformly in bending, and a torque. The latter is absorbed exclusively by the torque tube on the outer wing portion, whereas in the center section the torque is also taken up by bending of the spars.

The accuracy of the stress analysis was checked on the finished wing by means of load tests up to the safe C load case. The agreement between the experimental and the mathematical data was close. The obtained wing torsion of 2.7° was sufficiently small. The flanges of the deeply cambered spars were of laminated fir. The fear of internal initial stresses in these spar flanges set up during manufacture were removed by experiments. Another difficulty was the determination of the safe stresses in the curved spar flanges and in the web supporting the spars at these points but the problem was successfully solved by destruction tests on two spars of 6.5 m (21.33 ft.) length. It was found that permissible edge stresses on the convex side of the compression flange were almost equal to the ultimate bending stress of a straight spar of the same dimensions, whereas on the concave side only the pure compression strength of the wood was reached.

In view of the high gliding speed it was very important to have the critical speed of the airplane at which flutter or buffeting occurs, high enough.

By virtue of the continuous wing covering the torsional stiffness of the wing is quite high. But to prevent any eventual flutter due to unbalanced ailerons, the aileron mass about the hinge axis was completely balanced. Subsequent experiments with test wedges revealed for the most unfavorable conditions a critical speed of 700 km/h (435 m.p.h.), which assured ample security in any steep glide.

The fuselage is of duralumin (681 ZB) in monocoque design with frame bulkheads and longitudinal channel sections, thus insuring commodious and unobstructed compartments (fig. 5). The longerons, bulkheads and stiffeners are open channel sections. The cabin extends over four main bulkheads, which are interrupted at the flanges for the stiffeners. All channels within this range of the cabin are riveted to the skin. The fuselage terminates in a system of longitudinal channels, resting on circular bulkheads and rivetod to the skin. The bulkheads themselves are not connected to tho skin.

The shell of the fuselage is not resistant to buckling but, since the skin between flanges and longitudinal channels are supporting, the amount of buckling under high stresses is permissible. Only at a few points near the main fittings for the wing we used thick shell plates to transmit local stresses.

The problem of fuselage size was twofold, since the produced as well as the permissible stresses are not determinable except by actual experiment.

The necessary strength data on curved, stiffened plates with skin alone not resistant to buckling were obtained from compressive, bending and torsion tests on cylindrical shells, in conjunction with destruction tests on a finished fuselage end. The accuracy of the stress distribution due to the windows and doors was checked in destruction tests of a specially built fuselage. In order to be able to apply the actual bending moments and cross stresses at the model the missing fuselage end was supplemented by a steel tube pyramid and the engine mount by an auxiliary structure. It supported the required ultimate loads of: horizontal tail surface load, vertical tail surface load and their superpositions and three-point landing without failure. In the load case: three-point landing with 10 percent overload, the fuselage finally failed in the field of the maximum cross force between the main bulkheads. The reinforced main plate back of the pilot's door buckled, and the support channels on the left side were crushed.

And now a few words about the structural details which will show that everything has been done to make the He 70 not only a fast, but also a safe and comfortable transport airplane.

The pilot sits in the middle of the fuselage and slightly elevated, to assure better visibility. The roof of his cabin is transparent and movable, his seat is vertically adjustable (fig. 6). Elevator and ailerons are wheel operated, the rudder by a foot pedal; lateral trimming balance is assured by auxiliary airfoil from the pilot's seat; no stabilizer setting is necessary; the controls are mounted on ball bearings. The wireless operator sits aft and to the right of the pilot. Right back of the pilot is a seat for the mechanic or a passenger.

The passenger cabin has a capacity of 2.7 m³ and a separate door. Each seat has a window and an arm rest. The cabin is equipped with hot-air heating and a ventilating system. Back of the passenger cabin is a baggage room. The windows are of shatterproof glass and large enough to serve as emergency exits.

The divided landing gear is retractable. The Faudi shock-absorber strut is hinged to the front spar of the wing, the supporting strut to the rear spar. The axle strut which absorbs all moments about the landing gear joint slides on a rail fastened at the rear spar.

The landing gear is outwardly drawn up in the wing by oil pressure and cable, the wheel resting between the two spars (fig. 7). Wheel brakes are used; the size of the tires is 900 by 200 mm (35.43 by 7.87 in.). The fairing plates fastened to the wheels form a perfect streamlining after retraction. The drag of the lowered landing gear is not abnormal, so that take-off and climb are not materially impaired.

A mechanical indicating device, a pin connected with the landing gear extends beyond the wing and indicates its momentary setting. Red and green lights in the cockpit indicate the extreme setting. An acoustic signal, a Bosch Klaxon, connected with the gas throttle sound a warning when the throttle is set to idling and stops after the wheels have been extended.

The tail skid, fitted with spring and oleo retracts with the landing gear.

The fuel supply of 430 liters (113.6 gal.) is carried in two wing tanks which are equipped with a dump mechanism. A turn of the jettison lever releases a spiral hose through which the whole supply is drained within one minute.

The power plant consists of a 12-cylinder BMW VI 6.0 Z engine without reduction gear, developing 660 hp. at 1600 r.p.m. Figure 10 shows the engine performance at full throttle against various r.p.m. The rotative speed depends on the attainable maximum horizontal speed of the airplane (fig. 8).

The test point at the left is taken from a DVL test report. It was used because it just happened to lie on the curve given by the BMW engine firm. The other two points correspond to the engine performances timed at 1600 and 1700 r.p.m. for the top speed flown of 362 km/h (224.9 m.p.h.) and subsequently 377 km/h (234.3 m.p.h.) (after the latest aerodynamic refinements - wing fillets). The dashed curve shows the engine r.p.m. at throttle speeds according to the formula

$$N_D = N_V \left(\frac{n_D}{n_V}\right)^3$$

The circles and speeds represent those flown with the airplane without wing fillets. Figure 9 shows this same throttle curve plotted against the originally obtained and obtainable speeds dependent on the engine performance. A speed of 377 km/h (234.3 m.p.h.) was obtained after the fillets had been fitted. The dashed line shows the extent of dependence of the flying speed of the finished He 70 on the engine performance. Figure 10 shows the horizontal speed to be only very little less with increased full load; the same graph also illustrates the effect of the full load on the landing speed and the great speed range.

As proved by the performance tests the He 70 is aerodynamically excellent; still further substantial speed increases could be obtained, however, according to these curves, by installing more powerful engines.

Specifically, the use of supercharged engines would result in very considerable improvement. To illustrate: with an engine of the same horsepower as the BMW VI, that is, 660 hp. but with a constant pressure height of 2000 m (6560 ft.) and 400 km/h (248.5 m.p.h.) for the He 70, it would amount to more than 440 km/h (273.4 m.p.h.) at a constant pressure height of 5000 m (16,400 ft.) (fig. 11). Unfortunately, we have no such engines in Germany. The performances of our fastest airplanes could be still further increased by reducing the unit engine weight, as seen from the following comparison:

One hears so often that the useful loads of the American airplanes are greater than ours. Look at table III.

The load of the Northrop "Delta" is actually 280 kg (617.3 lb.) greater, but, this difference is readily explained when the engine weight is examined. The BMW engine weighs 275 kg (606.3 lb.) more than the Wright-Cyclone, the performance of the BMW is 660 hp. at sea level, that of the Wright-Cyclone 720 hp. at 7710 ft. In spite of that the speed of the He 70 is still 377 km/h (234.3 m.p.h.) as a result of its aerodynamic qualities, against 338 km/h (210 m.p.h.) despite 7710 ft. according to a report from the manufacturer of the Northrop "Delta". Neither is the superior speed of the He 70 due to aerodynamic advantages of the water-cooled BMW engine over the American air-cooled engines. This is proved by the elaborate American experiments as briefly reported in "Aviation Engineering, May 1933, during the Langley Field Conference. An air-cooled engine with N.A.C.A. cowling was stated to have a drag of 22.55 kg (49.7 lb.), a corresponding water-cooled engine with exposed radiator, 21.95 kg (48.4 lb.) and a radiator within the cowl, 23.20 kg (51.1 lb.).

The He 70 made its first flight on December 1, 1932, at the tenth anniversary of the Heinkel airplane company. In the following spring, 1933, the He 70 established, without the fillets, the eight records given in table IV.

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.

TABLE I

Data on High-Speed Airplanes

No.	Year	Type	Full load G	N	Wing area F	Wing loading G/F	Speed V	High speed fig.	Remarks
			kg	hp.	m^2	kg/m^2	km/h	η/c_w	
1	1928	Lockheed "Air-Express"	1735	410	25.5	68.0	258	19.0	-
	1929	" "	"	"	"	"	269	21.6	aerod. refinements
	1930	" "	"	"	"	"	282	24.9	NACA cowling
2	1930	Lockheed "Vega"	1831	420	25.5	76.8	275	22.5	" "
	1931	" "	2143	"	"	84.0	288	25.8	" "
	1932	" "	2146	425	"	84.2	288	25.5	" "
3	1930	Lockheed "Sirius"	2360	420	24.6	95.8	280	22.9	" "
	1931	" "	2088	"	25.5	81.8	280	23.8	" "
4	1931	Lockheed "Orion"	2361	525$^{1)}$	25.5	92.6	345$^{2)}$	35.6	" " and retract. land. gear
	1932	" "	"	"	"	"	345	35.6	
5	1930	Consolidated "Fleetster 17"	2406	575	29.12	82.7	288	21.5	NACA cowling
	1931	" " "	"	"	"	"	288	21.5	" "
	1932	" " 17-A	2950	600	33.5	88.0	304	28.0	" "
6	1930	Northrop "Alpha"	1907	425	27.4	69.5	280	25.3	" "
	1931	" "	2134	420	"	77.8	272	23.5	" "
7	1933	Northrop "Delta"	3180	720$^{3)}$	33.7	94.4	338$^{3)}$	25.5$^{3)}$	" "
8	1931	B.F.W. "M-28"	2750	525	25.6	107.5	255	14.4	-
9	1932	Junkers "Ju 60"	3100	525	35.0	88.6	280	26.1	NACA cowling and retr. land. gear
10	1932	Heinkel "He 70"	3350	660	36.5	91.8	377$^{4)}$	52.8	retr. land. gear

1) 500 hp. at 7000 ft. 2) V = 225 m.p.h. at 7000 ft. 3) at 7700 ft. 4) G = 6400 lb.

kg x 2.20462 = lb. m^2 x 10.7639 = sq. ft. kg/m^2 x 0.204818 = lb./sq. ft. km x 0.62137 = mi.

TABLE II

Weights and Performances of the He 70

Weights:		
Structural weight, inclusive of cabin equipment and radio	2340 kg	(5158.8 lb.)
Useful load, 350 kg (771.6 lb.) of fuel, and 7 passengers with baggage	1010 kg	(2226.7 lb.)
Total weight	3350 kg	(7385.5 lb.)
Wing loading	91.7 kg/m²	(18.78 lb./sq.ft.)
Engine:		
BMW VI 6.0 Z, 660 hp. at 1600 r.p.m. Power loading	5.1 kg/hp	(11.09 lb./hp.)
Performance:		
Maximum speed with G = 2900 kg (6393.4 lb.)	377 km/h	(234.3 mi./hr/)
Operating speed with G = 3325 kg (7330.4 lb.)	323 km/h	(200.7 mi./hr.)
Landing speed (no flaps)	104 km/h	(64.6 mi./hr.)
Climbs to 1000 m (3280 ft.)(with G = 3325 kg) in	3.4 min.	
Rate of climb with $\gamma = 1.1$ kg/m³ (0.069 lb./cu. ft.)	4.6 m/s	(15.1 ft./sec.)
Service ceiling	5700 m	(18,700 ft.)
Cruising radius with 350 kg (771.6 lb.) fuel	925 km	(574.8 mi.)

TABLE III

Comparison of "He 70" with Northrop "Delta"

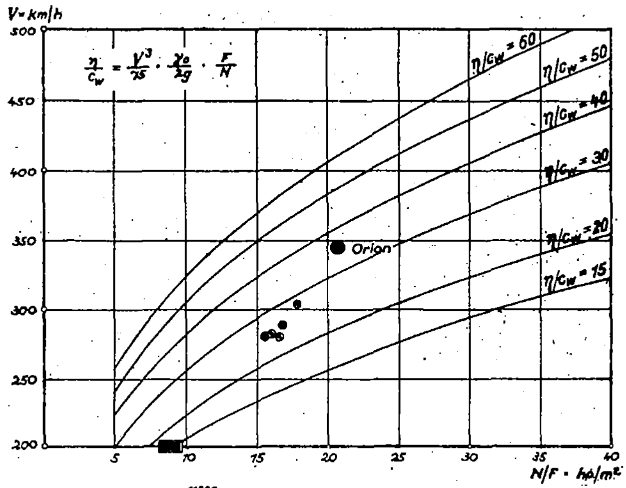
	Heinkel "He 70"	Northrop "Delta"
Full load	3350 kg	3180 kg
Structural weight including cabin equipment and radio	2310 kg	1860 kg
Useful load	1040 kg	1320 kg
Engine	BMW VI 6.0 Z	Wright Cyclone Sr. 1820 F-3
Weight	720 kg	445 kg
Performance	660 hp (at sea level)	720 hp (at 2350 m)
Speed	377 km/h (at sea level)	338 km/h (at 2350 m)

TABLE IV

Eight Records

No.	Date	Distance km	Useful load kg	Speed km/h
1	March 22, 1933	1000	0	347.5
2	" 24, "	2000	0	345.3
3	" 22, "	1000	500	347.5
4	April 28, "	100	500	357.4
5	" " "	100	1000	357.4
6	March 14, "	500	0	348.9
7	" " "	500	500	348.9
8	April 28, "	500	1000	355.3
Maximum speed after fitting wing fillets				377

kg X 2.20462 = lb. m X 3.28083 = ft. km X 0.62137 = mi.

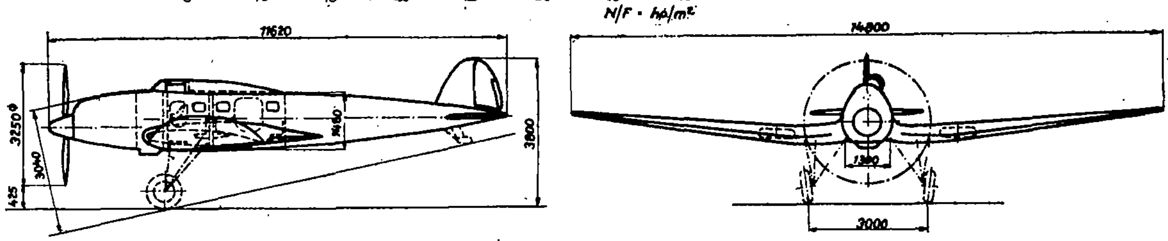


⊙ ---- U.S. high speed airplanes up to 1932

● ---- Lockheed Orion

▬ ---- German single and multi-engined transport planes.

Figure 1.- Maximum speed V versus area to horsepower ratio.



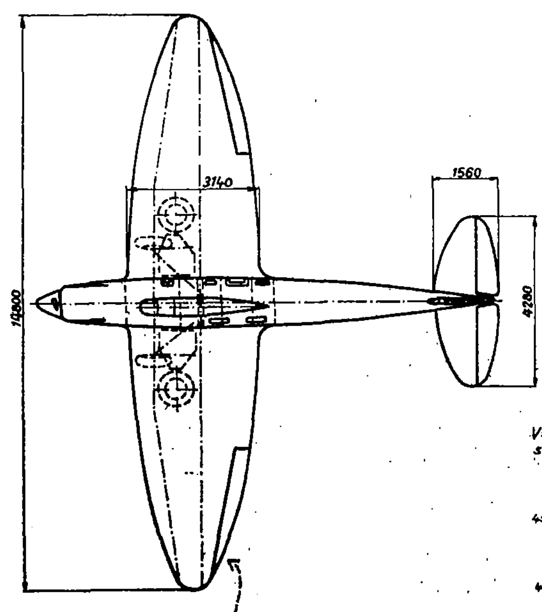


Figure 2.- The Heinkel He 70 high speed mail plane.

⊙ ---- U.S. high speed airplanes up to 1932

● ---- Lockheed Orion

⊕ ---- Junkers Ju 60

● ---- Heinkel He 70

▬ ---- German single and multi-engined transport planes

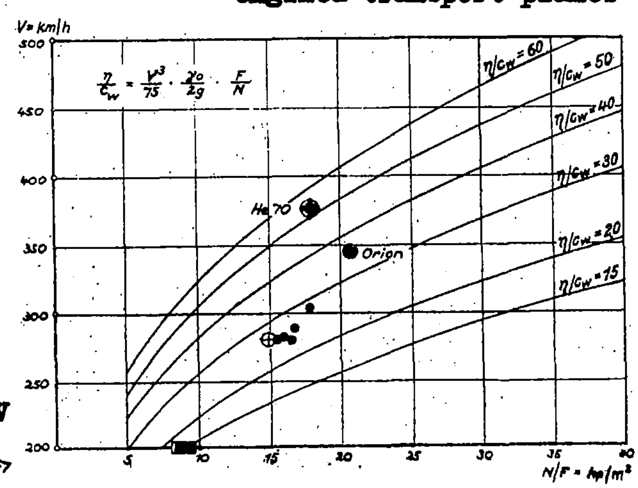


Figure 4.- Maximum speed V versus area to horsepower ratio.

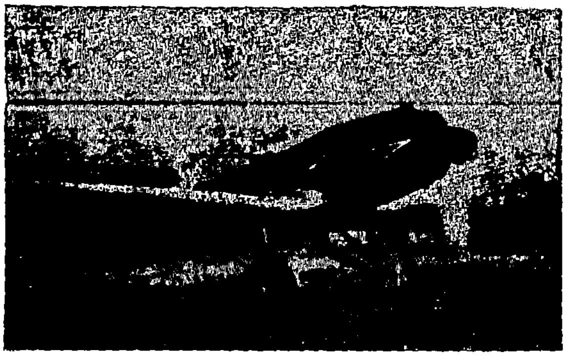


Figure 3.- Heinkel He 70 test run.

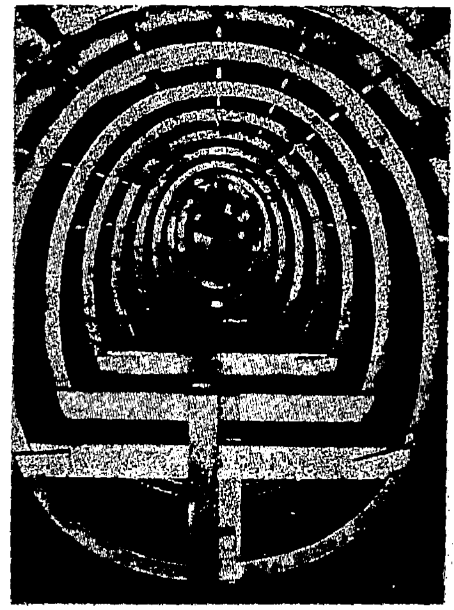


Figure 5.- Interior view of fuselage.

Figure 6.- Pilot's cockpit.

Figure 7.- Landing gear strut with wheel hub retracted.

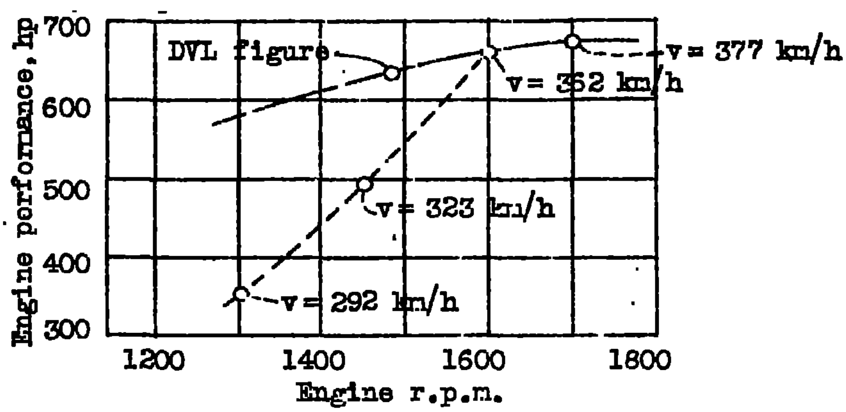


Figure 8.- Performance and throttle curve of BMW VI engine.

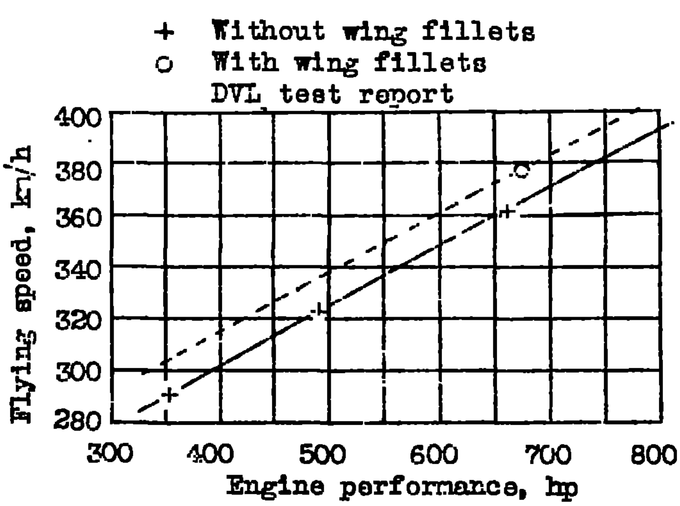


Figure 9.- Horizontal speed versus engine performance.

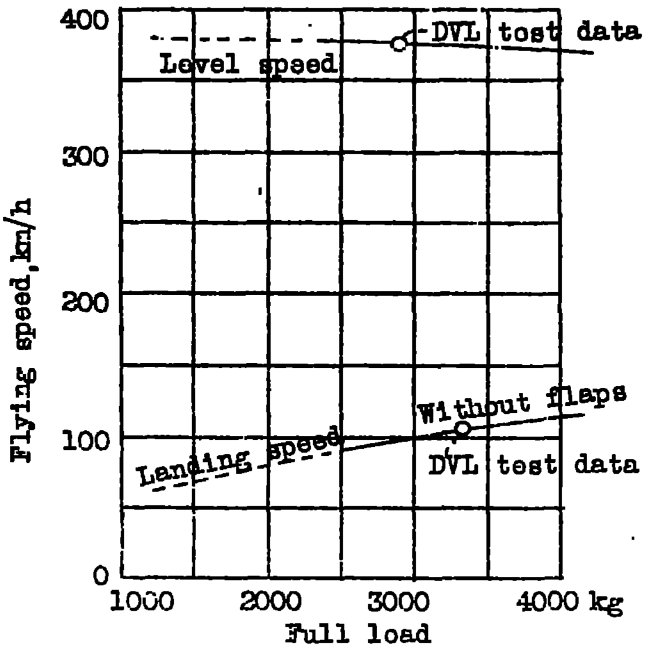
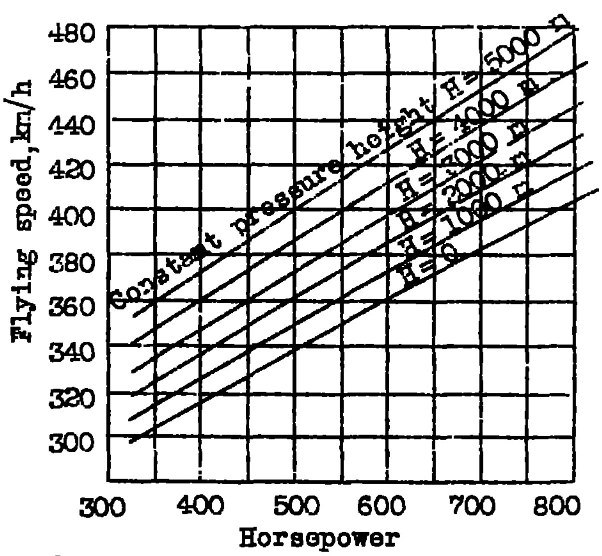


Figure 10.- Landing and horizontal speed versus full load.



Reduced according to sea level performance of the He 70 in the DVL test flights. G = 3350 kg.

Figure 11.- Comparison of horizontal speeds of the He 70 with supercharged engines.